concerned, we believe they are not satisfied with import duties, and want prohibition of import for a time, with permits to import in special cases. Many consumers have stated their preference for a system of subsidies to enable prices to be low enough to compete with foreign goods. Such a scheme naturally offers difficulties, and there would need to be assurance that efforts at improvement are being made. There seems to be no reasonable objection to the price being made as nearly as possible equal to that of the foreign article, so that the competition should become one of quality. The Bill, however, will probably be passed, although it may still be possible to insert provisions to enable free import to recognised scientific institutions. Such permits must be of a general character, not requiring renewal, and not demanding the intervention of the Customs or other Government Department. No special licences for individual cases would be satisfactory.

How obstructive to scientific progress the Customs regulations may be is shown by letters that have appeared in these columns. The question of books is a very serious one. Incidentally, reference may be made to the increasing difficulty of publication of scientific papers, which seems to be greater in England than in other countries. But here again what is wanted is a general fall in prices, and this can be brought about only by a return to normal trade relations throughout the world.

Much stress was laid by certain speakers in the House of Commons on the necessity of our industries as a national insurance in case of future war. The only remark that need be made in this place is that the most important matter is to keep abreast of scientific work in other countries. Restriction of research is likely to do more harm than the more or less ineffective artificial protection of a few industries would do good. It is to be hoped, therefore, that institutions in which such scientific research is carried on will be placed beyond the effect of the new restrictions on import.

Steam and Thermodynamic Theory.

Properties of Steam and Thermodynamic Theory of Turbines. By Prof. H. L. Callendar. Pp. xi+531. (London: Edward Arnold, 1920.) 40*s*. net.

IN this substantial volume Prof. Callendar has set his seal to the experimental and theoretical investigations of the properties of steam on which he has been engaged for many years. By these investigations, which have done much to advance technical thermodynamics, Prof. Callendar has made the engineering world his debtor. It is twenty-one years since he first published, in the Proceedings of the Royal Society for June, 1900, his paper on "the thermodynamical properties of gases and vapours as deduced from a modified form of the Joule-Thomson equation, with special reference to the properties of steam."

With the publication of the book now under review Prof. Callendar's theory comes of age. The book leads up to, and includes, his steam tables, which were issued separately five or six years ago and are accepted as the standard tables, at least by English engineers. Here the author describes, much more fully than before, the basis of the tabular work, discusses its agreement with the latest results of observation, and replies to objections that have been taken to his method on the part of some American writers. Into this controversial matter there is no need to enter here: the replies will have answered their purpose if they succeed in removing misconceptions regarding the scope and character of Prof. Callendar's fundamental work, which, indeed, his own earlier papers can scarcely be said to have presented in a form that made its meaning very clear or its importance obvious.

Perhaps for that reason engineers were slow to appreciate the practical bearing of Prof. Callendar's treatment of the properties of steam. The first of them to do so was Prof. Mollier, of Dresden, himself distinguished for original contributions to technical thermodynamics, who in 1906 published a set of tables and diagrams for steam based on the Callendar characteristic equation. Shortly afterwards the methods of Prof. Callendar and the tables and diagrams of Prof. Mollier were brought to the notice of English engineers by the present writer in the third edition of his book on "The Steam-Engine and other Heat-Engines."

Prof. Callendar's own tables, published in 1915, embody the results of a more complete application of his methods, and make use, in some particulars, of later data. They give all the necessary figures for properties of steam throughout the range of temperature and pressure which is usual in the practice of steam engineering. It is the essence of Prof. Callendar's method to secure results which will be thermodynamically consistent with one another, and will also agree with the results of experiment within a limited but sufficient range. His characteristic equation makes no pretension to be applicable outside that range.

In this respect it differs from characteristic equations such as those of Van der Waals or Clausius. But within the range of its application it gives results the agreement of which with the results of direct observation is as close as the agreement of one set of observations with another.

Prof. Callendar treats steam as a gas the deviations of which from perfection may be expressed by writing the characteristic equation in the form

$$V=RT/P-c+b,$$

where RT/P is the ideal volume of a perfect gas, b is the "co-volume," or volume occupied by the molecules—a volume which is not reducible by lowering the temperature—and c is what he calls the "coaggregation volume," which is the volume lost by the interlinking or pairing of molecules. He treats c as a function of the temperature only, within the range of temperature and density to which the equation applies, making c vary as $1/T^n$. He makes the further assumption that when the pressure is indefinitely reduced the specific heat of the gas is not altered by changes of temperature within that range. These assumptions not only accord with the results of experiment; they also have the great practical advantage of yielding expressions that are easily integrable for all the properties of steam with which the engineer is concerned, such as the total heat, the internal energy, the entropy, the specific heat, the Joule-Thomson cooling effect, and the thermodynamic potentials of Willard Gibbs. Prof. Callendar shows that, by help of his equation and of the assumption which has been stated, expressions for all these quantities are readily obtained by applying the usual thermodynamic relations, and, being so derived, the resulting numerical values, which he calculates for his tables, are necessarily consistent amongst themselves. It was the absence of mutual consistency that was perhaps the gravest defect in earlier tables of the properties of steam.

The range through which the Callendar characteristic equation is applicable may conveniently be described as the range through which the Amagat isothermals (of PV and P) are sensibly straight lines. The slope of these lines depends on the values of the quantities b and c in the characteristic equation: it is, in fact, equal to $b-c$. But to determine the constants of the equation Prof. Callendar relies mainly on experiments of the porous-plug type, which measure the cooling effect produced by forcing the gas through a constricted orifice. In his own experiments of this kind he employed an ingenious differential device which, with his platinum thermometers, went far to eliminate sources of error that affected the somewhat discordant results obtained by other observers. When a gas passes a throttling orifice of any kind, under conditions which prevent loss or gain of heat by conduction, there is one function of its state that undergoes no change, namely, the function which Willard Gibbs represented by the symbol χ. This function is equal to the internal energy *plus* the thermal equivalent of the product PV. It is now usually called the "total heat"—a name first applied to it by Prof. Callendar himself. Its value in technical thermodynamics was emphasised by Prof. Mollier, who introduced charts exhibiting the total heat in relation to other functions of the state, notably the entropy. The "heat-drop," or loss of total heat which the working fluid undergoes in passing through a turbine or engine of any type, is the basic quantity in all calculations of thermodynamic performance. It is equally useful as a means of analysing the reversed thermal cycle that is gone through by a refrigerating machine, for which purpose tables or charts are needed of the total heat of such working substances as carbonic acid and ammonia.

Besides his detailed tables of all the properties of steam, saturated or superheated, within the usual working range, Prof. Callendar gives in this volume an empirical table of the properties of saturated steam up to the critical point, to "serve as a guide for future work." In the extended table the critical temperature is taken as 374° C., in accordance with the results of Traube and Teichner, and the latent heat is calculated by a formula of the Thiesen type, which makes it vanish at the critical point. The critical volume becomes 3·25 c.c. per gram. The critical state lies, of course, far outside the region within which Prof. Callendar's characteristic equation is applicable. He deals with it in a separate chapter, which includes an interesting discussion of recent experiments on carbonic acid by Jenkin and Pye.

Another section of the book deals with the theory of flow through nozzles and of the steam turbine. In this field also Prof. Callendar's work has been of fundamental importance by showing that the conditions of adiabatic flow are not, in general, equilibrium conditions, but involve complications due to supersaturation. By taking account of the effects of supersaturation he has brought the theory of steam-jets into harmony with the results of observation, removing what had been a puzzling discrepancy and explaining why it is that the measured discharge from a nozzle is actually greater than the limit which, according to the older theory, would be found even under frictionless conditions. The same considerations are here applied to the analysis of what occurs in the steam turbine as a whole.

The book is completed by three appendices; the first is on general thermodynamic relations, and the second is on the use of a steam diagram in which the co-ordinates are the total heat and the logarithm of the pressure. The third appendix gives the steam tables in the same form as that in which they were separately presented in his earlier publication.

It is not a book for beginners: it will be intelligible only to those who have a working knowledge of general thermodynamics and are fairly familiar with the use of partial differential coefficients. But engineers and physicists who have this equipment will find it a valuable work of reference. They will welcome so detailed a statement of original views and methods from one whom they gratefully recognise as a leader and a pioneer. Prof. Callendar writes with the authority of an investigator whose knowledge of steam and its properties is probably unique.

J. A. EWING.

Ore Deposits of Utah.

The Ore Deposits of Utah. By B. S. Butler, G. F. Loughlin, V. C. Heikes, and Others. (U.S. Geol. Surv. Professional Paper 111.) Pp. 672+lvii plates. (Washington, D.C.: Government Printing Office, 1920.) 1½ dollars.

THE series of monographs in preparation by the Geological Survey of the United States to summarise existing knowledge of the ore deposits of the separate American States will render readily available much valuable information now dispersed through a voluminous and scattered literature. The first of the series was on New Mexico (1910). The second deals with Utah, an area of special interest as regards both its geological structure and the variety of its ore deposits. The study of Utah has introduced many new conceptions into structural geology; some of them, like that of the laccolite, a term introduced for the Henry Mountains by Gilbert, have been fully confirmed; others, such as the support to antecedent rivers by the oft-quoted case of the Green River, have been set aside by fuller knowledge of the facts, or, like the igneous sequences proposed by Dutton and Spurr, are dismissed as too uncertain.

Utah has given exceptionally clear evidence of the importance of block faulting in determining the existing relief, and of the cause of such faulting by subsidence after long periods of igneous activity and earth movement. The views of le Conte and Suess, based on the earlier studies of Utah, are fully justified by the latest contributions to its geology. The tectonic history of the region presents a significant coincidence with that of Africa in the importance of east-to-west folds in the late Cretaceous, and of subsequent north-to-south faults that may be even still in progress.

The economic geology of Utah is especially instructive on account of the remarkable variety of its ore deposits. Some, such as the silver sandstones, are well known owing to the controversy as to the origin of the ores; the authors of this survey adopt Lindgren's conclusion that they were sedimentary grains concentrated by hot water in consequence of the igneous intrusions. Probably the most valuable general conclusion in the volume (pp. 196–201, and the instructive diagram, Fig. 31) is that the quantity of the ore deposits beside masses of intrusive igneous rock depends on the lowering of the surface by denudation. This principle had been previously used to explain the contrast between the gold veins in the adjacent fields of Bendigo and Castlemain in Victoria, and also the fact that the ores beside the granites of Burma are richer beside narrow than beside the wider outcrops. It receives its fullest and most authoritative expression in this volume. The clearness of the diagrammatic figures of the ore bodies and tectonic structures is an especially notable feature of this important and well-executed monograph.

Medical Science and Practice.

(1) *Obstetrics: Normal and Operative.* By Prof. G. P. Shears. Third edition, revised by Dr. P. F. Williams. Pp. xxii+745. (Philadelphia and London: J. B. Lippincott Co., 1920.) 35*s.* net.

(2) *Principles and Practice of Operative Dentistry.* By Dr. J. S. Marshall. Fifth edition. Pp. xxix+711+xvi plates. (Philadelphia and London: J. B. Lippincott Co., 1920.) 35*s.* net.

(3) *Diagnosis and Treatment of Brain Injuries: With and Without a Fracture of the Skull.* By Prof. W. Sharpe. Pp. vii+757. (Philadelphia and London: J. B. Lippincott Co., 1920.) 35*s.* net.

(4) *Lippincott's Quick Reference Book for Medicine and Surgery.* By Dr. G. E. Rehberger. (Philadelphia and London: J. B. Lippincott Co., 1920.) 63*s.* net.

MESSRS. LIPPINCOTT'S series of textbooks on medical subjects is well known in this country. Many of the volumes, as is the case with two of the four under review, have already reached the third or later editions.

Like nearly all American books, they are